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G6C
G6R

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(54) Machines for dismantling decommissioned nuclear reactors

(57) A machine for dismantling, unloading and transferring to a disposal facility, nuclear reactor structure and/or components, which have been irradiated during operation of the reactor. The machine includes in one example a gantry (12) mounted on a rigid, undismantled part of the reactor such as rails (10) on the refuelling level (9) of the reactor, a carriage (14) angularly movable on the gantry, a platform (14¹) movable linearly on the carriage, a mast (16) on and axially movable relative to the platform, a manipulator (17) mounted on the mast for angular and linear movement relative thereto, a variety of tools (18) selectively mountable on the manipulator for effecting dismantling of reactor structure and/or components, and hoist means (26) movable along a beam (21) rotable about the reactor centre line and alignable with other beams (23, 24) to allow transfer of the hoist means from one beam to another. Alternative arrangements for varying the elevation of the mast are also disclosed.

Fig. 3.

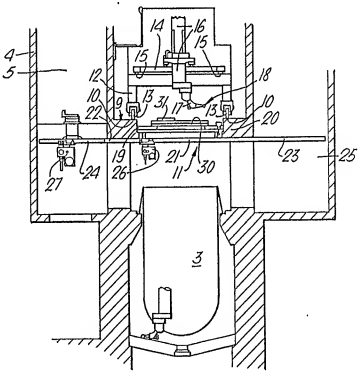

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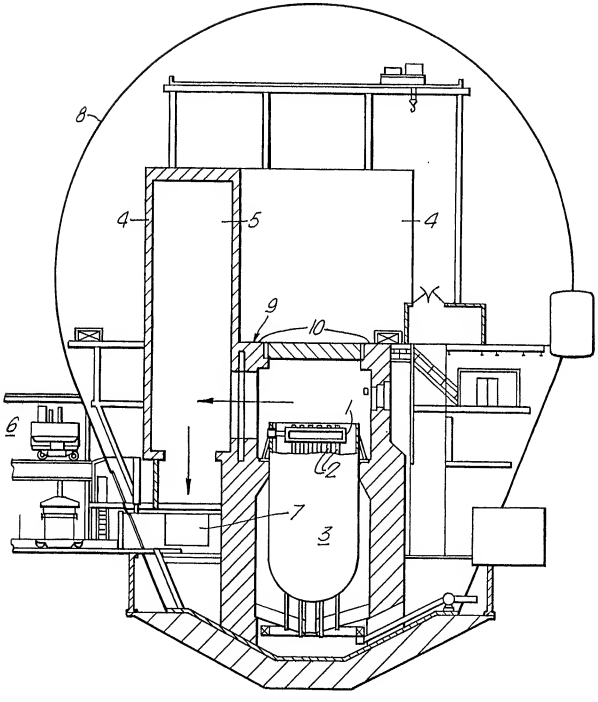
Fig.1.



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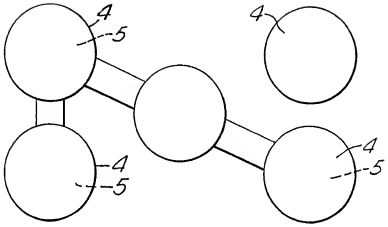
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Fig. 3.

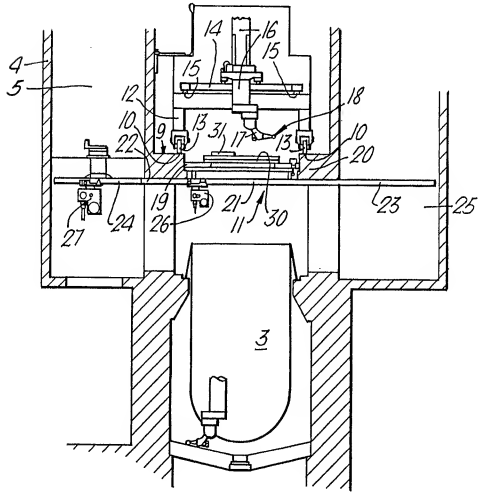
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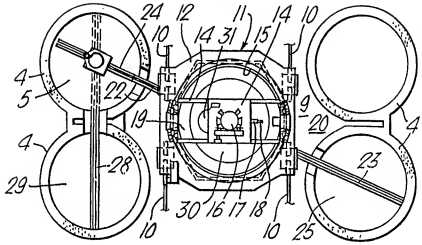
Fig. 4.



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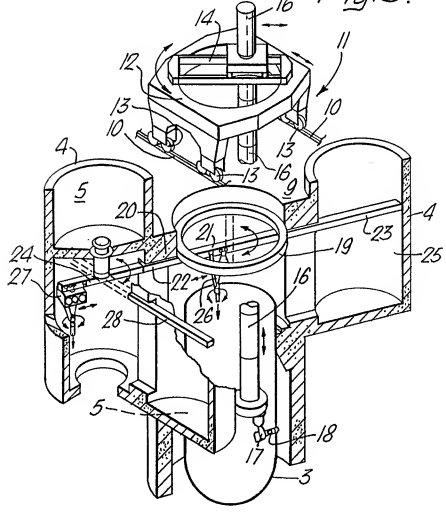

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Fig. 6.

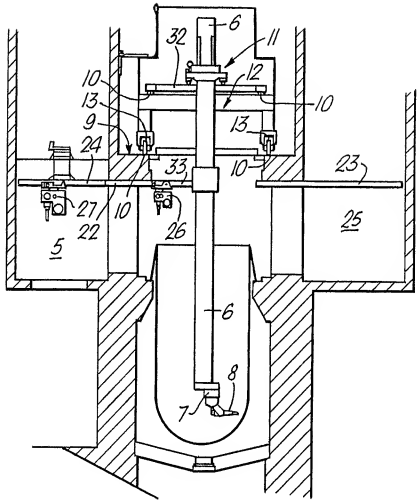
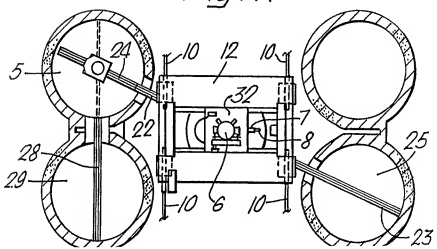


Fig. 7.



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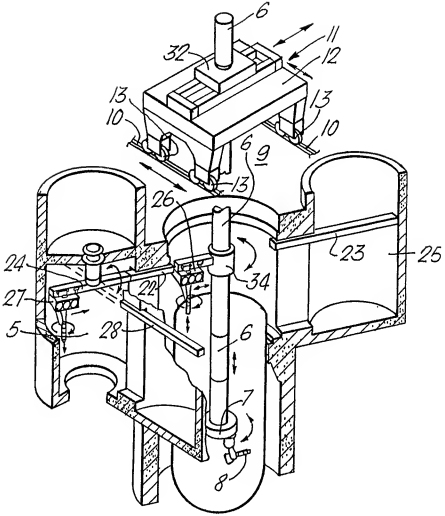

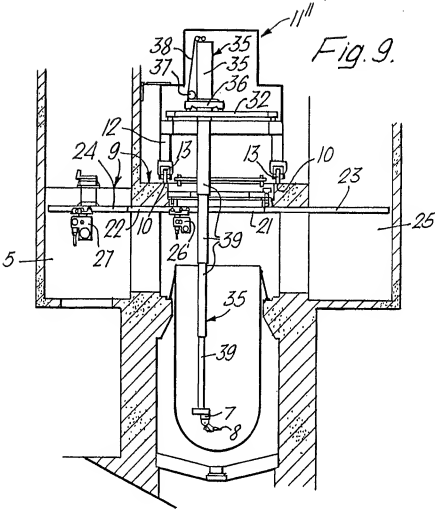
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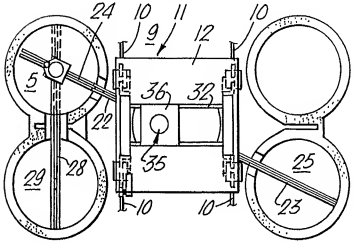
Fig. 9.

Fig. 10.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SPECIFICATION

Machines for dismantling decommissioned nuclear reactors

This invention relates to the decommissioning of nuclear reactors which are considered to have completed their operational life, and in particular, to machines for effecting dismantling of the reactor structure in a controlled and safe manner.

When a nuclear reactor has reached the end of its planned operational life, the alternatives, after removal of the nuclear fuel and reactor coolant, are to cover the whole structure with adequate shielding, such as a mound of soil, and take precautions for the covered reactor to be preserved so shielded for all time as a permanent 'memorial', or to dismantle the structure of the reactor and dispose of the dismantled material in small amounts in conventional safe storage facilities, and as a result, restore the reactor site to its pre-building state. The latter course is to be preferred, especially in view of doubts concerning the practicability of preserving the shielding integrity of the whole reactor structure over the period of thousands of years necessary before biologically unsafe amounts of radioactivity will have decayed away.

To put the present invention into context, consider a conventional gas-cooled, graphite moderated, nuclear reactor which has within a pressure vessel a core including the moderator and the fuel elements, the latter being capable of being charged and discharged by a refuelling machine, and surrounding the core, heat exchangers which remove heat from coolant heated by circulation through the core and employ the removed heat to generate electricity for example employing steam and turbine. When such a reactor has completed its operational lifetime, let it be assumed that a decision has been reached to dismantle the reactor and restore the site. After normal discharge of the fuel elements and blowdown of the coolant gas it is considered acceptable from a safety point of view to employ conventional dismantling techniques for removal of the turbines, heat exchangers, refuelling machine and, with adequate temporary shielding, the top dome of the pressure vessel so as to expose the core. In order to dismantle and remove the pressure vessel and to unload and transfer to a disposal facility the graphite moderator (which is in discrete block form) and other vessel internals, a machine is required which will perform these operations safely and expeditiously, and it is an object of the present invention to provide such a machine.

According to the invention, a machine for dismantling, unloading and transfer to a disposal facility nuclear reactor structure and/or components which have been irradiated during operation of the reactor, has a gantry, means for mounting the gantry on a rigid part of the reactor which has not yet been dismantled, a carriage movable on or about said gantry, a mast mounted movably or non-movably on said carriage, a manipulator mounted movably on said mast and capable of supporting and operating a variety of tools for effecting dismantling of said structure and/or components, and hoist means, separate and separately operable from said manipulator, for effecting, either in conjunction with said manipulator or without, unloading and transfer of dismantled structure and/or components, all the functions of said machine being controllable remotely. The hoist means may be movable along a diametrically or radially mounted beam which is rotatable about the reactor vessel centre line. The hoist means may be capable of being transferred to other beams, either fixed or rotatable.

Alternatively, the hoist means may be mounted rotatably on the said mast and be also capable of radial movement relative to the mast. The mast may be a rigid single structure and the carriage be movable to raise or lower the mast, or alternatively the mast may be made up of a plurality of sections so that its elevation can be changed either by adding or subtracting sections or by telescoping or extending.

Constructional examples of machine according to the invention will now be described with reference to the accompanying diagrammatic drawings, whereIn:-

Figure 1 is a side view in section and
Figure 2 a plan view of a nuclear reactor which it is intended to dismantle with the aid of one of the machines shown in Figures 3-10,
Figure 3 is a side view,
Figure 4 is a plan view and
Figure 5 a perspective view of one construction of machine in operative position,
Figure 6 is a side view,
Figure 7 a plan view and
Figure 8 a perspective view of another construction of machine in operative position,
Figure 9 is a side view and
Figure 10 a plan view of a modification.

Like reference numerals in the drawings illustrate like parts.

Referring firstly to Figures 1 and 2, these Figures show in diagrammatic form the gas-cooled, graphite moderated, nuclear reactor known as the Windscale Advanced Gas-Cooled Reactor (WAGR), which has now completed its useful life and is to be dismantled. The reactor core (not shown), which includes the graphite moderator and fuel element channels, and other internals such as core support (not shown), hot box 1 and refuelling standpipes 2, are contained in a pressure vessel 3, the upper dome and the upper parts of the standpipes 2 of which are shown removed. The volume which the upper dome occupied is intended to be employed for a dismantling, unloading and transferring machine, such as one of those subsequently described herein and referred to hereinafter inclusively as a 'handling machine'. The reactor also has four heat exchanger housings 4, from which the heat exchangers have been dismantled and removed by conventional means with shielding precautions, since the radioactivity level of these structures is such as to permit such operations. One of the buildings 4 (when emptied) is employed as a temporary repository 5 for dismantled material, in which sorting and designation for packaging in a communicating building 6

is carried out, small size material which can be disposed of in bulk being dropped into a waste container 7 beneath the temporary repository 5. The outer containment 8 of the reactor is retained and helps to retain integrity during dismantling and related operations. The packaging building 6 is outside the containment 8 and communicates via an air lock (not shown).

The refuelling floor level is designated 9 in Figure 1, and is provided with rails 10 for the reactor refuelling machine (already removed) to run on.

Figures 3-5 show the reactor with a handling machine 11 in position. The machine 11 consists of a gantry 12 with wheels 13 running on the said rails 10, and a carriage 14 able to move angularly relative to the gantry 12 on a rail 15 on the gantry 12 (see particularly Figures 4 and 5). The carriage 14 carries on a platform 14' movable linearly on the carriage 14 a mast 16 able to be extended and made shorter relative to the carriage 14 in a direction parallel to the axis of the reactor pressure vessel 3. There is a manipulator 17 mounted on the lower end of the mast 16 and moveable in an angular and linear manner relative thereto, the manipulator 17 being capable of carrying cutting and the like tools 18 by means of which the pressure vessel 3 and vessel internals may be dismantled prior to transfer for packaging. The mast 16 can be extended or made shorter by adding or taking away separate sections provided with appropriate secure fastening expedients (not shown) of conventional kind.

A ring girder 19 carried by the reactor concrete structure 20 provides a track for a slew beam 21 to be rotated about the vessel centre line and in one angular position to be aligned and registered with fixed beams 22, 23. The beam 22 is an intermediate between the beam 21 and another slew beam 24 rotatable about the centre line of that heat exchanger housing 4 which is used as the temporary repository 5. The beam 23 is a fixed beam extending into another heat exchanger housing 4, designated 26 and employed as a maintenance cell. There are for example two hoists 25, 27 movable along the beams 21, 22, 23, 24, the hoist 26 operating normally over the vessel 3 and movable into the cell 25, and the hoist 27 being normally situated over the repository 5 and on the slew beam 24 but being movable from the beam 24 to the beam 21 via the beam 22 and vice versa for transfer of material between the area of vessel 3 and the repository 5. There is another fixed beam 28 with which beam 24 can be aligned and registered and which extends between repository 5 and another of the empty heat exchanger housings 4, this being designated 29 and employed for temporary waste storage. The hoist 27 can be made to travel from beam 24 to beam 28 and vice versa. There is remotely controlled mechanism provided (not shown) for controlling and rotating the beams 2 and for moving and operating the hoists 26, 27.

It is envisaged that the manipulator 7 and tools 8 are to be employed to cut the material of the pressure vessel into manageably-sized pieces, and that the hoist 26 with the aid of conventional gripping or possibly magnetic lifting means on the end of the hoist cable (none shown), be used to transfer the pieces when cut to the repository 5 and thence to the packaging building 6 or to the temporary storage area 29. Furthermore, the hoist 26 would be used to pick up and transfer dismantled moderator blocks piecemeal to 5, 6 or 29.

In order to permit short-term access to the gantry 12, carriage 14 and the upper area occupied by these components, and to obviate undue exposure of the components to radiation from vessel 3 and the vessel internals, rotatable shielding 30 with an eccentrically disposed removable shield circle 31 is provided to span the ring girder 20 (see Figures 3 and 4), the mast 6 being extendable, and the hoist 26 being operable, through the hole provided in the shielding 30 suitably rotated, when the circle 31 is removed. Figure 5 shows the mast 6 in its extended position with the manipulator 7 and tool 8 in position for attacking the material of vessel 3, whereas Figure 3 shows the mast 6, manipulator 7 and tool 8 in retracted position.

In an alternative construction, illustrated in Figures 6, 7 and 8, the handling machine 11' has a gantry 12 similar to the gantry 12 of the Figures 3-5 construction, with wheels 13 able to run on the existing rails 10 on the reactor charge face 9. A carriage 32 is mounted on the gantry 12 for cross-travel thereon. A mast 6 similar to the mast 6 of the Figures 3-5 construction is mounted on the carriage 32 and carries, as in the Figures 3-5 construction, a manipulator 7 capable of holding a tool 8.

The main difference from the Figures 3-5 construction is that there is a beam 33 radially mounted on a collar 34 rotatable on the mast 6. The beam 33 can be rotated by remote control of the collar 34 and can be made to align and register with an intermediate beam 22 or with a fixed beam 23, as was the beam 21 in the Figures 3-5 construction, except that, in this case, alternative but not simultaneous registration is only possible. There is a slew beam 24 and fixed beam 28 as in the Figures 3-5 construction, and a hoist 27 operates between vessel 3 space and repository 5 or storage 29.

A hoist 26 operates on beam 33 and can move on to beam 23 to operate in maintenance cell 25 or on to beam 24 via beam 22 to operate in cell 5. As in the Figures 3-5 construction, the mast 6 can be extended and shortened by adding or subtracting sections.

The construction shown in Figures 9 and 10 provides a handling machine 11" which combines the slew beam 21 construction shown in Figures 3-5 with the gantry 12 and cross-travel carriage 32 of the Figures 6-8 construction, but is varied by having a telescopic mast 35 mounted on a platform 36 on the carriage 32 and having equipment, diagrammatically indicated as a windlass 37 and cable 38, for controlling the telescoping and untelescoping of the sections 39 of the mast 35.

In a modification, not illustrated, the slew beam 21 of the Figures 3-5 construction can, instead of being mounted on the separate ring girder 20 on the reactor building, be suspended rigidly from the rotatable carriage 14 of that construction, and be rotatable by virtue of the controlled rotation of that carriage 14 on the gantry 12, the beam corresponding to slew beam 21 thereby having its loading

transferred to the rails 10 via the wheels 13 of gantry 12.

In another modification, not illustrated, the mast may be a rigid structure, and the elevation of the manipulator and tooling mounted thereon can be varied by providing means, operable remotely, for raising and lowering the carriage relative to the gantry, whose elevation is fixed by being mounted on the said rails.

CLAIMS

1. A machine for dismantling, unloading and transferring to a disposal facility, nuclear reactor structure and/or components which have been irradiated during operation of the reactor, such machine having a gantry, means for mounting the gantry on a rigid undismantled part of the reactor, a carriage movable on or about said gantry, a mast mounted movably or non-movably on said carriage, a manipulator mounted movably on said mast and capable of supporting and operating a variety of tools for effecting dismantling of said structure and/or components, and movable hoist means separate and separately operable from said manipulator, for effecting, either in conjunction with said manipulator or without, unloading and transfer of dismantled structure and/or components, all the functions of said machine being controllable remotely.

2. A machine according to claim 1, wherein the said hoist means is or are movable along a beam mounted diametrically or radially for rotation about the centre line of the reactor vessel.

3. A machine according to claim 2, wherein said hoist means is or are capable of being transferred to other beams, either fixed or rotatable.

4. A machine according to any of the preceding claims, wherein the said hoist means includes more than one hoist, operable and movable separately.

5. A machine according to either of claims 1 and 4, wherein the said hoist means is or are mounted on said mast so as to be capable of both rotatable and radial movement relative thereto.

6. A machine according to any of the preceding claims, wherein the mast is a rigid structure and the carriage is moveable upwardly or downwardly relative to the gantry so as to raise or lower the mast.

7. A machine according to any of claims 1-5, wherein the mast is made up from a plurality of sections, and sections can be added to or taken from the mast so as to vary its elevation.

8. A machine according to any of claims 1-5, wherein the mast is telescopic, and means are provided, operable remotely, for telescoping or extending the mast to give a required elevation.

9. For dismantling, unloading and transferring to a disposal facility nuclear reactor structure and/or components which have been irradiated during operation of the reactor, a machine substantially as described with reference to the accompanying drawings.

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